

The hydraulics review module is intended to provide the driver trainee a summary of hydraulics and formulas that have been taught at various times in the fire service.

The “Q” Formula

Hand Lines		Supply Lines	
Hose size	Friction Loss Formula	Hose size	Friction Loss Formula
1 ½”	$24Q^2$	3” Hose	Q^2
1 ¾”	$12Q^2$	3 ½” Hose	$Q^2 \div 3$
2”	$6Q^2$	4” Hose	$Q^2 \div 5$
2 ½”	$2Q^2$	5” Hose	$Q^2 \div 15$
¾” Booster	$1100Q^2$		
1” Forestry	$150Q^2$		

ESTIMATING SQUARES

For the purposes of pump calculations, the square of any number that includes “½” can be estimated by multiplying the first whole number by the next higher whole number. For example:

$$(1.5)^2 = 1 \times 2 = 2 \text{ (actually} = 2.25)$$

$$(2.5)^2 = 2 \times 3 = 6 \text{ (actually} = 6.25)$$

MFRI Friction Loss for Attack Lines

30 psi Friction Loss per 100 foot Section

Size of Hose	Maximum Flow
1-1/2” Line	125 gpm
1-3/4” Line	150 gpm
2 “ Line	200 gpm

MCFRS Accepted Friction Loss per 100’ Hose

	1 ½” Hose	1 ¾” Hose	2” Hose
100 GPM	30psi	10psi	5psi
150 GPM		30psi	15psi
200 GPM		50psi	25psi
250 GPM			40psi

GENERAL NOZZLE PRESSURES

Standard Fog	100psi	Smooth Bore Handline	50psi
Fog Master Stream	100psi	Smooth Bore Master Stream	80psi
Low Pressure Fog	75psi		

FORMULAS

$$EP = NP + FL + D \pm EL$$

Engine Pressure = Nozzle Pressure + Friction Loss + Device \pm Elevation

$$NR = 1.57 \times D^2 \times NP \text{ (Smooth Bore Nozzle)}$$

Nozzle Reaction = $1.57 \times (\text{Diameter of Nozzle Tip})^2 \times \text{Nozzle Pressure}$

$$NR = 0.0505 \times Q \times \sqrt{NP} \text{ (Fog Nozzle)}$$

$$GPM = 29.7 \times D^2 \times \sqrt{NP} \text{ (Smooth Bore Nozzle)}$$

Gallons per minute = $29.7 \times (\text{diameter})^2 \times \sqrt{\text{nozzle pressure}}$

RULE OF EIGHT'S FOR SMOOTH BORE NOZZLE TIPS

This formula uses the diameter of the tip size in eighths of an inch plus a factor of 2 to rough calculate the gallons per minute flow from a smooth bore nozzle.

Example: 1" Tip = $0/8 + 2 = 200$ GPM (A 1" tip has zero eighths associated with it so it is zero eighths (0/8) plus 2 to equal 200 gallons per minute flow)

1" Tip = $0/8 + 2$	$0 + 2 = 200$ GPM
1 $\frac{1}{8}$ " Tip = $1/8 + 2$	$1 + 2 = 300$ GPM
1 $\frac{1}{4}$ " Tip = $2/8 + 2$	$2 + 2 = 400$ GPM
1 $\frac{3}{8}$ " Tip = $3/8 + 2$	$3 + 2 = 500$ GPM
1 $\frac{1}{2}$ " Tip = $4/8 + 2$	$4 + 2 = 600$ GPM
1 $\frac{5}{8}$ " Tip = $5/8 + 2$	$5 + 2 = 700$ GPM
1 $\frac{3}{4}$ " Tip = $6/8 + 2$	$6 + 2 = 800$ GPM
1 $\frac{7}{8}$ " Tip = $7/8 + 2$	$7 + 2 = 900$ GPM
2" Tip = $8/8 + 2$	$8 + 2 = 1000$ GPM

SITUATIONAL CALCULATIONS

Elevation Loss/Gain: Changes in elevation add or reduce pressure in the hoseline. ± 5 psi per 10 feet of elevation change or per floor when fire is inside a building.

Standpipe and Sprinkler Connections: 150 PSI at Base and 5 PSI per Floor unless otherwise specified on the connection. 200 PSI at Base above the 10th Floor.

Master Stream Devices: Nozzle Pressure + 10 PSI for the device. Older devices with multiple intakes and stream straightener Nozzle Pressure + 20 PSI.

Non-pre-piped Aerial Apparatus: Calculate friction loss for the flow in hose in ladder bed 3" or 3 ½" and 100 feet long + 10 PSI for the Siamese appliance + 10 PSI for nozzle appliance + nozzle pressure + elevation loss.

Pre-piped Aerial Ladders and Aerial Towers: Pump per the specifications of the apparatus.

Relay Residual Pressure: 50 PSI for 3" Hose
20 PSI for 4" and 5" Hose

Drafting: Maximum theoretical lift is 33.9 feet at sea level. The actual lift capacity varies based upon pump condition and elevation.

Metro Standpipe: Fill the system using hydrant pressure until Master Intake and Discharge Gauge read the same pressure. Allow for elevation gain when pressurizing the system, i.e. +5psi per 10 feet of drop. Hydrant pressure alone may sufficiently pressurize the system and hydrant pressure may even need to be gated back to compensate for the pressure.

Bresnan Cellar Nozzles:

Elkhart 2½" Nine Outlet (3-9/16"; 3-5/8"; 3-1/2")– 480gpm at 100psi or 340gpm at 50psi

Elkhart 2 ½" Six Outlet (3-9/16"; 3-5/8") – 385gpm at 100psi or 275gpm at 50psi

Akron 2 ½" Nine Outlet (3-1/4"; 6-13/32") – 250gpm at 100psi

Akron 1 ½" Six Outlet (3-1/4"; 3-5/16") – 95gpm at 50psi

ESTIMATING HYDRANT CAPACITY

$$\frac{\text{Static} - \text{Residual}}{\text{Static}} \times 100 = \% \text{ drop}$$

<10% drop: 2x water available

<25% drop: 1x water available

>25% drop: less than 1x water available